

## **DEPLOYABLE ANTENNA REFLECTOR**

[0001] This application claims the priority of European Patent Application No. 02017163, filed July 31, 2002, the disclosure of which is expressly incorporated by reference herein.

### **SUMMARY OF THE INVENTION**

[0002] The invention relates to a deployable antenna reflector.

[0003] Future communication satellites require medium size lightweight deployable antenna reflectors which can be stowed during launch on a satellite in a minimized available envelope and are deployed during mission.

[0004] It is the object of the invention to provide a deployable antenna reflector having a minimum envelope in its stowed configuration.

[0005] The reflector according to the invention is a so-called thin sheet reflector comprising sheet-like deployable panels preferably made of CFRP (carbon fiber reinforced plastic) arranged around a fixed central reflector dish. The rotation axes of the deployable panels are tilted with respect to the center point of the central dish in order to optimize the storage envelope. The panel movement is not directed radially with respect to the center point of the reflector dish but shows a certain deviation.

[0006] The reflector according to the invention allows to deflect the deployable panels during storage on their upper edges and to achieve the nominal well-defined parabolic reflector contour after deployment by relaxing the panel deflection.

[0007] Thus, a geometric minimization of the envelope of the stowed reflector is achieved not only by optimization of the panel deployment kinematics but also by deflection of the panels in the stowed configuration.

[0008] The diameter of the reflector in the deployed configuration is preferably in the range between 3 or 6 m. The preferred frequency band is X-Band or higher.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0009] These and other objects, features and advantages of the present invention will become more readily apparent from the following detailed description of currently preferred configurations thereof when taken in conjunction with the accompanying drawings wherein:

[0010] Fig. 1 shows a three-dimensional view of the reflector in the stowed configuration;

[0011] Fig. 2 shows a three-dimensional side view of the reflector partially deployed;

[0012] Fig. 3 shows a three-dimensional view of the reflector fully deployed;

[0013] Fig. 4 shows a three-dimensional top view of the reflector fully deployed;

[0014] Fig. 5 shows a three-dimensional view of a deployment damping device of the reflector (on one panel only);

[0015] Fig. 6 shows a three-dimensional view of a launch lock device of the reflector;

[0016] Fig. 7 shows a three-dimensional view of a detail of the launch lock device (compression rope and unloaded release damping rope);

[0017] Fig. 8 shows a three-dimensional view of a panel hinge and the panel deployment drive (spring);

[0018] Fig. 9 shows a top view of the reflector with the sheet-like panels being omitted for reasons of clarity.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0019] Fig. 1 illustrates the reflector according to the invention in its stowed configuration, i.e., during launch. The individual sheet-like panels P made of CFRP are hingedly connected to a central supporting ring R which provides the structural interface to the satellite and to the tripod/feed TP assembly of the reflector as well. In addition, the central dish CD (Fig. 4) of the reflector, which is also designed as a thin-walled CFRP membrane, is fixedly connected to the central supporting ring R. Preferably, each thin sheet-like panel P is supported by a hollow CFRP rib RB which connects a panel P to the central dish DC via mechanical bushings. As can be understood from Fig. 1, the upper inner edges of the thin sheet-like panels P are bent in the stowed configuration. Upon deployment, relaxation of the panels P takes place (Figs. 2 to 4).

[0020] Fig. 4 shows the reflector in its fully deployed configuration. The central dish and the deployed sheet-like panels arranged around the central dish together form the overall reflector surface.

[0021] It is an essential feature of the invention that the deployment axis of each sheet-like panel P is tilted with respect to the center of the reflector in order to optimize geometrically for minimum stowed envelope. In other words, the longitudinal axis (alongside the ribs RB) of each individual sheet-like panel P is not oriented radially with respect to the center point of the central dish CD but in an inclined orientation in order to achieve geometric minimization during storage. As can be best seen in Fig. 4, the longitudinal axis of each panel is tangent to a circle having the center point of the central dish CD as its center.

[0022] The aspect of tilted rotational axis' with respect to the center point of the central dish is further explained by Fig. 9. It depicts a reflector according to the invention (top-view, the sheet-like panels have been omitted for the sake of clarity). The hinges H of the sheet-like panels P are arranged on a circle around the center point M of the central dish CD. The rotational axis RA of each hinge H is oriented in such a way that it does not form a tangent to said circle.

[0023] Preferably, the individual panels are not coupled after deployment in order to achieve a final parabolic contour which is not sensitive to any cross coupling effects between the panels. Each individual panel provides a well-defined parabolic contour and the upper rim of each panel can be fine-tuned in height completely independently from the other panels.

[0024] On top (as seen in the stowed configuration) of each panel P and preferably supported by a rib RB, a metal launch lock bracket LLB is mounted in order to form a closed form-locking structural ring in the stowed configuration (Fig. 6). This structural ring is loaded by a circumferential rope CRO (Fig. 7) allowing to compress the ring segments formed by the brackets LLB with respect

to each other during launch in order to form a stiff structural ring transferring moments and lateral forces as well. All launch loads are guided through the panel ribs RB down to the structural interface on the central supporting ring R.

[0025] To release the reflector, the compression rope CRO is cut (Fig. 7) and the deployment is initiated by means of torque springs TSP present at each hinge H of a sheet-like panel P and acting on the rotation axis thereof (Fig. 8). Turning now to Fig. 5, during deployment, the motion is damped by means of a damping device DD which is preferably mounted on top of a panel P. The damping device DD shown in Fig. 5 is fit into one launch lock bracket LLB', the shape of which has been adapted accordingly. A thin rope DR (Figs. 5, 7) guided along all launch lock brackets LLB is pulled off a small cable drum CDR attached to the damping device DD so that the overall release motion of all panels P is damped simultaneously. The damping device may be an eddy current damping device but any other kind of damping device may be used. Synchronization of the deploying panels P is achieved inherently by the reflector design concept (Fig. 2). Only in the final deployed end position all panels are located one beside the other (with a certain overlap between neighboring panels; see Fig. 4) and no longer one behind the other.

[0026] After complete deployment about the spring loaded panel rotation axis close to the lower edge of each individual panel, the deployed end position is kept by way of a magnetic end stop element attached to the central supporting ring. This interface mates to the very end of the panel rib which carries an adequate metallic endstop fitting. The torque spring TSP still acting on the deployment RA axis suppresses residual backlash in the deployment hinge H.

[0027] The structural ring R is designed as a hollow CFRP ring providing the end stops for the deploying panels (Fig. 3) as well as the bearing of the deployment axis RA of each individual panel P.

[0028] Although the present invention has been illustrated and described with respect to exemplary embodiment thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omission and additions may be made therein and thereto, without departing from the spirit and scope of the present invention. Therefore, the present invention should not be understood as limited to the specific embodiment set out above but to include all possible embodiments which can be embodied within a scope encompassed and equivalent thereof with respect to the feature set out in the appended claims.